

# Transmission characteristics—A-Law

## Transmission characteristics for IPE

Tables 24 through 38 provide the transmission characteristics for IPE.

### Frequency response

Frequency response (attenuation distortion) at a given frequency is the difference between the loss at that frequency and the loss at 2820 Hz. Table 24 shows the minimum and maximum loss differences at significant frequency breakpoints for 2-wire and 4-wire interfaces.

Table 24  
Frequency response—A-Law

| Frequency (Hz)                                                                                                       | 2-wire interface (dB) |         | 4-wire interface (dB) |         |
|----------------------------------------------------------------------------------------------------------------------|-----------------------|---------|-----------------------|---------|
|                                                                                                                      | Minimum               | Maximum | Minimum               | Maximum |
| 200                                                                                                                  | 0.0                   | +5.0    | 0.0                   | +3.0    |
| 300                                                                                                                  | −0.5                  | +1.0    | −0.3                  | +0.3    |
| 400                                                                                                                  | −0.6                  | +2.0    | −0.5                  | +0.5    |
| 600                                                                                                                  | −0.6                  | +0.7    | −0.5                  | +0.5    |
| REF                                                                                                                  | −0.6                  | +0.7    | −0.5                  | +0.5    |
| 2400                                                                                                                 | −0.6                  | +0.7    | −0.5                  | −0.5    |
| 3000                                                                                                                 | −0.6                  | +1.0    | −0.5                  | +0.9    |
| 3400                                                                                                                 | −0.6                  | +3.0    | −0.5                  | +1.0    |
| 3600                                                                                                                 | 0.0                   | —       | 0.0                   | —       |
| <b>Note:</b> Positive values denote loss; negative values denote gain (measured at 2820 Hz with 0 dBm0 input level). |                       |         |                       |         |

## Overload level

Overload levels are measured with respect to the zero-level point in the PBX, which is defined as having an overload point of +3 dBm in an analog-to-digital conversion.

Therefore, the overload level in the receive direction is defined as the analog signal level (at the port interface) with an average power that is 3 dB greater than that of the signal, which after encoding produces the equivalent of the digital milliwatt (PBX zero-level point). The overload level in the transmit direction is defined as the analog signal level (at the port interface) with an average power that is 3 dB greater than that of the signal, which after decoding results from the equivalent of the digital milliwatt. Table 25 shows the overload levels in both the receive and the transmit directions.

**Table 25**  
**Overload level—A-Law**

| Type of circuit                                                   | Overload level (dBm)           |                                 |
|-------------------------------------------------------------------|--------------------------------|---------------------------------|
|                                                                   | Receive<br>(analog to digital) | Transmit<br>(digital to analog) |
| Line                                                              | +6.5                           | +2.5                            |
| CO trunk                                                          | +3.0                           | +6.0                            |
| Tie trunk                                                         | +3.5                           | +3.5                            |
| Tie (4-wire)                                                      | +3.0                           | +4.0                            |
| <b>Note:</b> For trunks, overload is specified for pads-out mode. |                                |                                 |

**Tracking error (gain variation with level)**

Level tracking measures how closely changes in the level of the input signal cause corresponding changes in output level. Tracking error, as shown in **Table 26**, is the deviation, in decibels, in gain or loss through specified ranges of input level relative to the deviation of a nominal 820-Hz input signal at the 0 dBm0 level.

**Table 26****Tracking error (gain variation with level)—A-Law**

| 820-Hz signal input (dBm0) | Variation in insertion loss (dB) |
|----------------------------|----------------------------------|
| –55 to –10                 | +0.5                             |
| –10 to +3                  | +0.5                             |

## Return loss

Return loss at an impedance discontinuity in a transmission path is the ratio, in decibels, of the power level of an incident signal to the power level of the resulting reflected signal. Echo return loss (ERL) is a weighted average of the return loss values over the frequency range of 500 to 2500 Hz.

Single-frequency return loss (SFRL) is the lowest value of nonweighted return loss occurring in the frequency range of 200 to 3200 Hz.

Table 27 shows return losses guidelines to satisfy the in-service requirements shown in Table 28. For each interface type (line and 2-wire trunk), a connection is made through the PBX to a 4-wire trunk interface, and the return loss is measured at both interfaces. All terminating impedances are 600 ohms.

**Table 27**  
**Return loss—in-service parameter values—A-Law**

| Connection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Echo return loss (dB) | Single-frequency return loss (dB)<br>(300–3200 Hz) | Notes |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------------------------------|-------|
| Line interfaces:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                                                    |       |
| Line side                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | >18                   | > 12                                               | 1     |
| 4-wire trunk side                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | > 21                  | > 19                                               | 2     |
| 2-wire trunk interfaces:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                    |       |
| 2-wire trunk side                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | > 22                  | > 17                                               | 2     |
| 4-wire trunk side                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | > 28                  | > 22                                               | 2     |
| <b>Note 1:</b> Terminating impedances are 600 $\Omega$ for a Meridian 1 line and 600 $\Omega$ and 2.16 $\mu$ F for a PBX line.<br><b>Note 2:</b> Terminating impedances are 600 $\Omega$ for a Meridian 1 line and 900 $\Omega$ and 2.16 $\mu$ F for a PBX line.<br><b>Note 3:</b> Terminating impedances are 600 $\Omega$ /900 $\Omega$ and 2.16 $\mu$ F for a 2-wire trunk.<br><b>Note 4:</b> Terminating impedances are 600 $\Omega$ for a Meridian 1 line and a 4-wire trunk.<br><b>Note 5:</b> The design requirements in this table are intended to ensure the satisfaction of the in-service requirements in Table 28. |                       |                                                    |       |

**Table 28**  
**Return loss—in-service attenuation—A-Law**

| Connection from<br>4-wire VNL tie trunk to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Circuit termination                                 | Echo<br>return loss | Single-<br>frequency<br>return loss | Notes |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|---------------------|-------------------------------------|-------|
| 4-wire VNL tie trunk<br>(through balance)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4-wire legs of hybrid<br>terminated in 600 $\Omega$ | > 27                | > 20                                | 1, 3  |
| 4-wire non-VNL tie trunk<br>(terminal balance)                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 600 $\Omega$ + 2.16 $\mu$ F at<br>distant PBX       | > 22                | > 15                                | 1, 3  |
| 2-wire non-VNL tie trunk<br>(terminal balance)                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 600 $\Omega$ + 2.16 $\mu$ F at<br>distant PBX       | > 18                | > 10                                | 1, 5  |
| CO or FX trunk<br>(terminal balance)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 900 $\Omega$ + 2.16 $\mu$ F at CO                   | > 18                | > 10                                | 2, 5  |
| PBX line<br>(terminal balance)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 600 $\Omega$ + 2.16 $\mu$ F                         | > 24                | > 18                                | 1, 4  |
| Meridian 1 line<br>(terminal balance)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 600 $\Omega$                                        | > 24                | > 18                                | 1, 4  |
| PBX line<br>(terminal balance)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Set off-hook                                        | > 12                | > 8                                 | 1, 4  |
| <p><b>Note 1:</b> Reference impedance is 600/900 <math>\Omega</math> + 2.16 <math>\mu</math>F.</p> <p><b>Note 2:</b> Reference impedance is 900 <math>\Omega</math> + 2.16 <math>\mu</math>F.</p> <p><b>Note 3:</b> Switchable pads set for nominal loss of 1 dB.</p> <p><b>Note 4:</b> Switchable pads set for nominal loss of 3 dB.</p> <p><b>Note 5:</b> If facility loss is less than 2 dB or adequate impedance correction is not provided, nominal loss has to be increased to 3 dB by switching in the 2 dB pad.</p> |                                                     |                     |                                     |       |

## Idle channel noise

Idle channel noise (noise in the absence of a signal) is the short-term, average, absolute noise power, measured with either psophometric weighting or 3000-Hz flat weighting, as shown in [Table 29](#):

- Psophometric weighting measures noise with a frequency weighting that reflects the characteristic of the human ear.
- 3000-Hz flat weighting measures noise with equal weighting for all frequencies in the 200–3000 Hz frequency range, measured at the PBX tip and ring.

**Table 29**  
**Idle channel noise—A-Law**

| Connection type | Psophometric<br>dBm0p | 3000-Hz flat noise (dBrn) |
|-----------------|-----------------------|---------------------------|
| Line to line    | < -65                 | < 29                      |
| Line to trunk:  |                       |                           |
| Trunk side      | < -65                 | < 29                      |
| Line side       | < -65                 | < 29                      |
| Trunk to trunk  | < -65                 | < 29                      |

## Longitudinal balance

Longitudinal balance (longitudinal to metallic), as shown in **Table 30**, defines the amount of metallic noise voltage (conductor to conductor) resulting from longitudinal voltage (conductor to ground) at the circuit input. The equation for calculating longitudinal-to-metallic balance is as follows:

$$\text{longitudinal balance (dB)} = 20 \log [V_s/V_m]$$

**Note:**  $V_s$  is the disturbing longitudinal voltage, and  $V_m$  is the resulting metallic voltage of the same frequency. Ideally, the metallic noise voltage is negligible and the longitudinal balance approaches infinity. All measurements are at the PBX tip and ring.

**Table 30**  
**Longitudinal balance—A-Law**

| Frequency<br>(Hz) | Minimum balance<br>(dB) | Average balance<br>(dB) |
|-------------------|-------------------------|-------------------------|
| 200               | 58                      | 63                      |
| 500               | 58                      | 63                      |
| 1000              | 58                      | 63                      |
| 3000              | 53                      | 58                      |

## Crosstalk

Crosstalk is the presence of unwanted voice signals coupled from one voice channel to another. Crosstalk not only is an annoyance to the listener but also is perceived as a violation of privacy. The crosstalk coupling attenuation for every combination of through connections in all interface categories, measured with input signals from 200 to 3200 Hz at 0 dBm0, are listed in [Table 31](#).

**Table 31**  
**Crosstalk—A-Law**

| Connection     | Crosstalk attenuation (dB) |
|----------------|----------------------------|
| Line to line   | > 75                       |
| Line to trunk  | > 75                       |
| Trunk to trunk | > 75                       |

## Quantization distortion

Quantization distortion, shown in [Table 32](#), is the distortion introduced when an analog signal is encoded to digital format, and then decoded to analog format. The quantization noise is the difference between the original analog speech signal and the analog signal (speech plus noise) resulting from the decoding process.

**Table 32**  
**Quantization distortion—A-Law**

| Input level (dBm0)                                                                             | Minimum signal/distortion ratio (dB) |
|------------------------------------------------------------------------------------------------|--------------------------------------|
| 0 to -30                                                                                       | 33                                   |
| -31 to -40                                                                                     | 27                                   |
| -41 to -45                                                                                     | 22                                   |
| <b>Note:</b> Input signal is 820 Hz sine-wave; output is measured with psophometric weighting. |                                      |



## Intermodulation distortion

With the input driven with a composite signal consisting of two sine-wave signals (denoted as  $f_1$  and  $f_2$ ), each in the range of 450–2050 Hz (but not harmonically related) and of equal level in the range of –21 to –4 dBm0, the system will not produce any  $2f_2-f_1$  intermodulation product at the output having a level greater than 35 dB below the power level of the composite input signal.

## Envelope delay

Envelope delay in a system is the propagation time through the system of a low-frequency sinusoidal envelope of an amplitude-modulated sinusoidal carrier. The carrier frequency is varied throughout the frequency range of interest to obtain the envelope delay as a function of frequency.

Relative envelope delay is the difference between the envelope delay at a given frequency and the global minimum envelope delay within the frequency range.

The values in [Table 33](#) indicate the relative envelope delay for the frequency ranges shown.

**Table 33**  
**Relative envelope delay—A-Law**

| Bandwidth (Hz)                                                        | Relative envelope delay (μs) |                                                    |
|-----------------------------------------------------------------------|------------------------------|----------------------------------------------------|
|                                                                       | Line-line                    | Line to trunk/<br>trunk to line/<br>trunk to trunk |
| 800 to 2700                                                           | 750                          | 375                                                |
| 1000 to 2600                                                          | 380                          | 190                                                |
| 1150 to 2300                                                          | 300                          | 150                                                |
| <b>Note:</b> The above limits apply to 95 percent of all connections. |                              |                                                    |

## Impulse noise

Impulse noise is noise bursts or spikes that exceed normal peaks of idle-channel noise. Impulse noise is measured by counting the number of spikes exceeding a preset threshold, as shown in [Table 34](#). Impulse noise level is measured as the number of counts above 55 dBmC during a five-minute interval, under fully loaded busy-hour PBX traffic conditions.

**Table 34**  
**Impulse noise—A-Law**

| Noise level<br>(dBmC) | Counts                 |
|-----------------------|------------------------|
| 55                    | 0 counts for 5 minutes |

## Echo path delay

Echo path delay, as shown in [Table 35](#), is the maximum round-trip port-to-port delay for all frequencies in the 200–3400 Hz range.

**Table 35**  
**Echo path delay—A-Law**

| Path               | $\mu$ s |
|--------------------|---------|
| Analog to analog   | 3000    |
| Analog to digital  | 2400    |
| Digital to digital | 2000    |

## Spurious in-band

**Table 36** specifies the image signal level required for in-band frequencies as measured selectively at the output port.

**Table 36**  
**Spurious in-band image signals—A-Law**

| Input signal         | Image signal level<br>(300–3400 Hz) |
|----------------------|-------------------------------------|
| 0 dBm0 (700–1100 Hz) | < –40 dBm0                          |

## Spurious out-of-band

**Table 37** specifies the image signal level required for out-of-band frequencies as measured selectively at the output port.

**Table 37**  
**Spurious out-of-band image signals—A-Law**

| Input signal            | Image signal level<br>(above 3–4 kHz) |
|-------------------------|---------------------------------------|
| 0 dBm0 (300 Hz–3.4 kHz) | < –25 dBm0                            |

## Discrimination against out-of-band signals

**Table 38** specifies the image signal level required for the designated input signals as measured at the output port.

**Table 38**  
**Discrimination against out-of-band signals—A-Law**

| Input signal             | Image signal level<br>(at any frequency) |
|--------------------------|------------------------------------------|
| –25 dBm0 (above 4.6 kHz) | 25 dB below level of test signal         |

## Transmission characteristics for PE

The transmission characteristics for PE are the same as for A-law IPE (see Tables 10 through 22). The PE overload levels are the same as for the  $\mu$ -Law overload levels in Table 23.